Giga-Voxel Structural Optimization

Aage, Niels; Andreassen, Erik; Lazarov, Boyan Stefanov; Sigmund, Ole

Published in:
Proceedings of the 30th Nordic Seminar on Computational Mechanics (NSCM-30)

Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

30th Nordic Seminar on Computational Mechanics
NSCM-30
J. Høgsberg, N.L. Pedersen (Eds.)
2017

GIGA-VOXEL STRUCTURAL OPTIMIZATION

NIELS AAGE*, ERIK ANDREASSEN*, BOYAN S. LAZAROV* AND OLE SIGMUND*

*Department of Mechanical Engineering, Solid Mechanics
Technical University of Denmark
2800 Lyngby, Denmark
e-mail: naage@mek.dtu.dk, web page: http://www.topopt.dtu.dk/

Abstract. The optimal topology of large structural systems has until now been concerned with the design of individual parts and not that of complete assemblies. However, due to recent advances in numerical algorithms tailored for large scale structural optimization this limitation can now be circumvented[1]. In this work we present several examples displaying how high resolution topology optimization can be used to obtain new, as well as already known[2], insight within the field of structural optimization. To demonstrate the capabilities of the developed framework we apply it to the design of the supporting structure of an entire wing from a Boeing 777 type aircraft[3]. In order to obtain a design that allows for details in the order of those found in existing wing structures, we discretize the wing with approximately 1.1 billion tri-linear hexahedral finite elements, yielding a maximum element size of $h = 0.8$cm. The design problem is solved using mathematical programming methods, filters from image processing and a multiple load case problem formulation. The results show how the topology of the wing structure has obvious similarities to nature's own light weight aviation design, i.e. bird bones, and how very fine resolution topology optimization provides new insight and possible weight savings for future aircraft designs.

Keywords: Topology optimization, giga resolution, high performance computing, finite element methods.

REFERENCES

[1] Aage, N., Andreassen, E. & Lazarov, B. S. Topology optimization using PETSc: An easy-to-use, fully parallel, open source topology optimization framework. *Structural and Multidisciplinary Optimization* **51**, 565–572 (2015).

[2] Sigmund, O., Aage, N. & Andreassen, E. On the (non-)optimality of Michell structures. *Structural and Multidisciplinary Optimization* **54**, 361–373 (2016).

[3] Aage, N., Andreassen, E., Lazarov, B. S. & Sigmund, O. Giga-voxel computational morphogenesis for structural design. *Nature,* **accepted** (2017).